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U.S. Department of the Interior

Alaska State Office
Division of Resources, Lands, and Planning
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Draft Operations Plan - 2012

Quantification of fish and aquatic insect tissue contaminants in the middle Kuskokwim River, Alaska

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1.0 Introduction

The Kuskokwim River drains a significant area of southwestern Alaska and supports a variety of resident and anadromous fish species. Subsistence uses of the land and wildlife have long sustained the peoples of the central Kuskokwim River basin in western Alaska (Brelsford et al. 1987). Within the last decade, increasing concerns associated with environmental contaminants and Alaska's fish have prompted the State of Alaska and various federal agencies to initiate monitoring programs. As a result of these efforts, an improved understanding of contaminants, such as methylmercury, within freshwater and anadromous fish species and the potential causal factors have been realized. Specifically in the Kuskokwim River basin, which is within what is often referred to as "the mercury belt" in Alaska, a number of mineral deposits have been mapped, that contain mercury (Hg), arsenic, antimony and other metals (Sainsbury and MacKevett, 1965). Some of these deposits were mined during the early and mid-20th century and remnant waste rock and processed ore from these operations are still present at some locations.

Resident fish species in the Kuskokwim and at least one tributary have been shown to contain elevated levels of mercury (Gray et. al, 2000). The relative contributions of mercury to the Kuskokwim ecosystem by abandoned mines is not well understood. The middle Kuskokwim River watershed, between Crooked Creek and Stony River runs through an area containing a number of known mercury deposits. The potential impacts of the mercury deposits on the aquatic food web, including species targeted for subsistence harvest, have not been thoroughly explored. Metals data collected from representative species at several trophic levels are needed to estimate the natural bioaccumulation metals in the aquatic ecosystem. This project seeks to collect the data needed to estimate natural levels of metals in sediments, water and levels of bioaccumulation across aquatic trophic levels. Study results will provide a more complete understanding of metals bioaccumulation in the aquatic foodweb in the middle Kuskokwim River and associated tributaries.

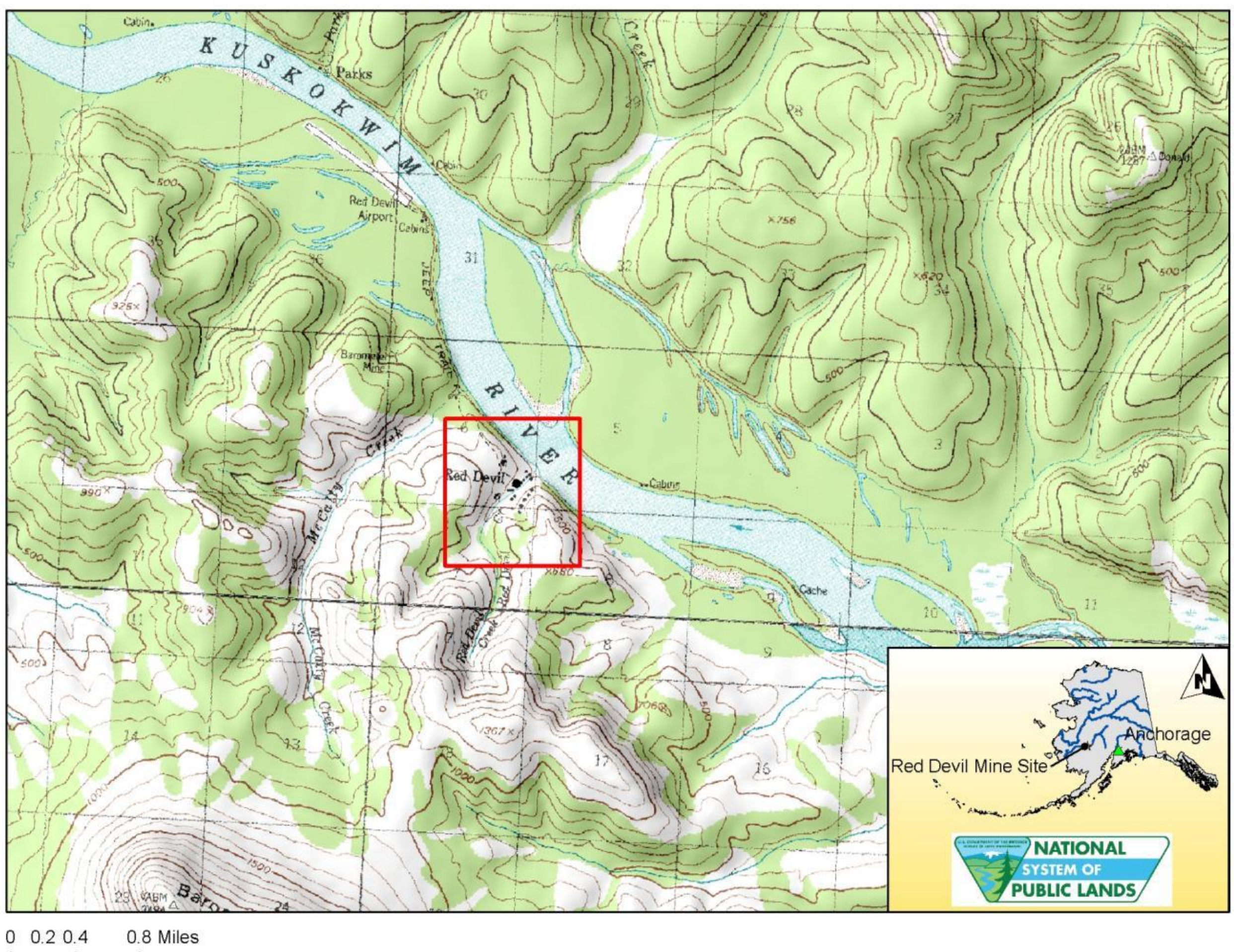
One of the largest abandoned mines in this section of the Kuskokwim River, the Red Devil Mine (RDM), is the site of an environmental investigation being conducted by the Bureau of Land Management (BLM). The data collected for this study will provide a regional context for site specific RDM data. Establishing natural background conditions is critical to assessing the RDM's relative contribution to mercury and other metals concentrations in the aquatic ecosystem of the middle Kuskokwim River. Aquatic macroinvertrebrate and fish tissue methyl-mercury and total mercury concentrations will be incorporated into the human health and ecological risk assessments to be conducted as part of the environmental investigation. .

1.1 Background

The presence of mercury deposits in the Kuskokwim River water is well documented and several of the larger deposits, including Red Devil (see Figure 1), have been extensively mined. The presence of methylmercury (MeHg) in resident fish in the lower and middle Kuskokwim has been the subject of study over the last 15 years.

The Alaska Department of Fish and Game (ADF&G) (2007) reported from a 2001-2003 survey of two villages on the middle Kuskokwim River within the area near Red Devil Mine, that households consumed 101-425 lbs of non-salmon fish on average annually. Non-salmon species typically are more susceptible to methylmercury bioaccumulation because they reside entirely within the freshwater system, as such these species have a higher risk of bioaccumulation through the aquatic food web (Hanisch 1998, Wolfe et al. 1998). This MeHg accumulation is especially evident in predatory, piscivorous (fish-eating) fishes (Lepak et al. 2009a), since bioaccumulation in fish tends to rise with an increase in age and fish sizes (Johnels et al. 1967; Jewett et al. 2003).

Figure 1. Map of the Red Devil Mine Area



Large, long-lived, resient species, such as burbot (*Lota lota*) and northern pike (*Esox lucius*) will be used to determine methylmercury bioaccumulation. Burbot and northern pike comprised 30-51% of the household fish consumption in villages near the Red Devil Mine site from 2001-2003 (ADF&G 2007). Additional sampling of lower trophic levels targeted at forage (prey) fish species and benthic aquatic macroinvertebrates will provide information methylmercury bioaccumulation in the aquatic foodweb. Wiener et al (2007) noted that top predators and 1-year old forage fish are the preferred indicators for monitoring trends in methylmercury bioaccumulation in freshwater ecosystems. Several studies in western Alaska have examined contaminants in fish species within the last 20 years. Within the last decade, the USFWS completed extensive sampling of the lowermost segment of the Kuskokwim and Yukon Rivers to determine methylmercury levels in northern pike (personal comm. A. Matz, USFWS 2010). Additionally, limited contaminant sampling of slimy sculpin in the Crooked Creek drainage, which joins the Kuskokwim River at the lowermost extent of the study area for this project, have occurred since 2004 (personal comm. E. Fleming, OtterTail Environmental 2010).

Jewett et al. (2003) summarized the results from 1987-2000 regarding methylmercury in select fish species in western Alaska rivers. The authors concluded that “further studies are needed to determine the environmental and human health impacts associated with mercury concentrations in western Alaska, especially in the context of potentially increased consumption of resident fishes when anadromous salmon catches are reduced” which have steadily occurred since 1998 (e.g., McNair and Geiger 2001). Gray et al. (2000) conducted a study near the RDM site to evaluate the effects of abandoned mercury mines on fish and the aquatic ecosystem. Fish tissue samples from Arctic grayling (*Thymallus arcticus*) and Dolly Varden (*Salvelinus malma*) collected downstream from mercury mines, including RDM, on the Kuskokwim River contained as much as 420 and 620 ng/g Hg (wet wt. muscle). These concentrations were several times higher than that in fish collected from regional baseline sites. Gray et al. (2000) concluded that elevated mercury concentrations in freshwater fish collected near abandoned Hg mines indicate that some biologically available mercury is bioaccumulated; however the sample size (n=8) was limited and did not include top-predatory species more susceptible to methylmercury bioaccumulation, such as northern pike.
In 2010, BLM and ADF&G sampled several hundred fish from the middle Kuskokwim River and eight tributaries. Sampling included both forage fish species and top-predatory fish, such as northern pike and burbot. These sampled were analyzed for 19 metals, including mercury, and the data are currently being analyzed by a USFWS Toxicologist. Preliminary results indicate a similar pattern of contamination as samples collected in the lower Kuskokwim and Yukon Rivers during the last decade with larger, older fish exhibiting higher concerntrations than smaller, younger fish. The data also indicated that top- predatory fish species had higher concentrations in the two major tributaries, the Holitna and George Rivers, compared to the middle Kuskokwim River samples. Preliminary results also indicated that forage fish collected from Red Devil Creek had increased concentrations of mercury compared to other sampled tributaries. Based on the preliminary results and the seasonal movements of fish in the Kuskokwim, George, and Holitna Rivers, additional sampling coupled with radio telemetry of northern pike and burbot is proposed for 2011-13. Additional tributary sampling is also proposed for Red Devil Creek, Egnaty Creek, and Cinnabar Creek, which is located in the upper Holitna River system and had a small historic mercury mining operation in its headwaters several decades ago.

1.2 General Study Objectives

This study is designed to build upon the work completed in 2010 and 2011 by addressing data gaps related to seasonal fish movements and increasing fish tissue samples throughout the study areas. The key elements of this study will:

- focus on all trophic levels from benthic macroinvertebrates to top-predatory fish species;
- target priority subsistence fish species;
- provide data on tributary fish community composition,
- provide insight into tributary watershed health using metric analysis of benthic macroinvertebrates for two tributaries;
- describe the seasonal distributions of two top-predatory fish species; and,
- include surface waters and streambed sediments sampling for contaminants, including Total Hg and MeHg, at the mouth of the Holitna River

The goal of this study is establish a baseline condition of several metals species, including mercury and methylmercury, in the Kuskokwim River and tributaries between Stony River and Crooked Creek. To date surface water and sediment samples and tributary fish tissue data have been collected. This phase of the project focuses on increasing our understanding of the seasonal fish movement patterns in relation to the potential sources and relative bioavailability of mercury in the Kuskokwim and sampled tributaries. Specific objectives and associated tasks for this project are relative to the period from July 2012 to March 2014, to northern pike ≥550, burbot ≥500 and Arctic grayling ≥330 mm Fork Length (FL). Objectives reference four sections (Figure 1):

- Lower Mainstem: 27-km reach of the mainstem Kuskokwim River between the mouth of the Holitna and the George River.
- Upper Mainstem: 153-km reach of the mainstem Kuskokwim River between Devils Elbow and the Takotna River.
- George River: 42-km reach of the George River between Julian Creek and the weir site.
- Upper Takotna: 80-km reach of the Takotna River upstream from the village of Takotna.
- Lower Takotna: 80-km reach of the Takotna River approximately 25 km upstream, from Takotna Village to the Kuskowkim River.

The specific study objectives for the 2012 Field Operation will be to:

a. Document the seasonal locations of northern pike radiotagged in the Upper Mainstem, the George River and Lower Takotna sections during aerial surveys conducted between summer 2012 and spring 2014.
b. Document the seasonal locations of Arctic grayling radiotagged in the George River, Upper Takotna and Lower Mainstem sections during aerial surveys conducted between summer 2012 and spring 2014.

c. Document the seasonal locations of burbot radiotagged in the Lower Mainstem section during aerial surveys conducted between summer 2012 and spring 2014.

d. Collect a biopsy sample (i.e., tissue punch) from all radiotagged northern pike, burbot, and Arctic grayling for contaminant testing;

e. Describe seasonal patterns of radiotagged Arctic grayling, northern pike, and burbot; and,

f. Describe the length composition of all northern pike, burbot, and Arctic grayling captured.

g. Analyze collected biopsy samples for the full suite of total metals, plus MeHg.

2.

2.0 Sampling Locations

During the summer of 2012, 35 burbot, 85 northern pike, 170 Arctic grayling will be radiotagged (Table 1). Tissue samples will be taken from all radiotagged northern pike and burbot. Tissue samples will not be taken from radiotagged Arctic grayling because annual mortality for these fish is generally significant (i.e. 50-60%) and the added stress of a biopsy sample (i.e. dermal punch) may be excessive. Instead, for each Arctic grayling radiotagged, a biopsy sample will be taken from a second or "paired" fish of similar size and the same location. Radio tags for northern pike and burbot will be monitored over a 2-year period - Arctic grayling for just one year based on the life of the tag. A combination of aerial surveys and 5 stationary tracking stations will be used to detect fish (Figure 1).

Within the study area, radio tags will be apportioned across length and geographic strata (Tables 1 and 2; Figure 1). Relative to length, the apportionment of radio tags seeks a balance between sampling older (i.e., larger) fish and sampling representatively to the length composition of the population. The apportionment of tags is skewed towards larger fish because of the likelihood that these fish may have higher levels of mercury. Relative to geographic strata, the apportionment will vary by species, available habitat, and time.

Northern pike: In the Lower Takotna section, efforts will be made to equally disperse the tags throughout the available slough habitat, which is abundant. For the Upper Mainstem, radio tags will be apportioned across the few major sloughs that exist, primarily within Vinasale, Wilson, and "Devils Elbow". Northern pike densities are very low in the George River, and fish will be radiotagged when (late June) and where (near the confluence with the East Fork) they are most prevalent based on previous sampling.

Arctic grayling: Within the George River and Upper Takotna sections, efforts will be made to equally disperse the radio tags. For example, deploying 8-10 tags every 5 km of river. In the Lower Mainstem, radio tags will be distributed in late June and mid October. In

June, Arctic grayling densities are very low and the crews will target creek mouths, such as Vreeland and Fuller. In mid October just prior to freeze up radio tags will be distributed near Sleetmute when Arctic grayling densities are apparently high and caught for subsistence. The aggregation of fish in the mainstem Kuskokwim River during mid October is of particular interest because these fish have the potential to disperse widely, spending their summers in clearwater tributaries and not in the glacial Kuskokwim.

Burbot: Radio tags will be deployed during early October in the Lower Mainstem. Catch rates are good in early October, in contrast to summer when catch rates are near zero for a hoop trap set overnight. Effort again will be made to distribute the tags equally along the length of the section while targeting areas that were productive in 2011.

In the event that sample sizes for a specific length and geographic strata cannot be achieved, efforts will first be made to distribute the extra tags into adjacent length categories, with a preference for larger fish. If this seems impractical, then the extra tags will be placed in nearby areas that appear to have the highest densities of fish while keeping with the original tag allocation by length strata. Because densities of Arctic grayling in the Lower Mainstem section may be very low, all extra tags will be deployed in mid October near Sleetmute.

3.0 Sample Methods

3.1 Biological Sampling

Northern pike will be captured primarily with hook-and-line gear and artificial lures. If needed, small mesh (i.e., 19-mm or ¾-in) gillnets of varying lengths and depths will be used. Sloughs and mouths of connecting streams and side channels will be targeted. Gillnets will be set opportunistically while angling and will be checked at regular intervals (<10 min) to minimize stress or mortality from released fish.

Burbot will be captured in commercially available hoop traps. The hoop traps are 3 m long with seven 6-mm steel hoops. Hoop diameters taper from 0.6 m at the entrance to 0.5 m at the cod end. Each trap has a double throat (tied to the second and fourth hoops) which narrows to an opening 10 cm in diameter. All netting is knotted nylon woven into 25-mm bar mesh, bound with #15 cotton twine, and treated with an asphaltic compound. Traps will be kept stretched with two sections of 19-mm polyvinyl chloride (PVC) pipe attached by snap clips to the end hoops. In general, burbot do not fully recruit to this gear until 450 mm TL and efficiency for fish ≥800 mm and larger decreases slightly, but the gear is still effective.

During fall ~20 hoop traps will be fished. Hoop traps will be set and allowed to fish overnight. The most productive sites from previous years will be targeted. Hoop traps will be baited with cut Pacific herring Clupea harengus placed in perforated plastic containers. One end of a 5- to 10-m section of polypropylene rope will be tied to the cod end of each trap, while the other end is tied off to shore. The traps will be fished on the river bottom near shore with the opening facing downstream.

All captured fish will be placed into an aerated sampling tub and sorted. Fish not selected for tagging will be sampled for length and returned to the water. For those fish that satisfy the length criteria, a radio tag will be surgically implanted following the basic surgical methods detailed by Brown (2006) and Morris (2003).

Biopsy samples for mercury analysis will be taken from all radiotagged burbot and northern pike, and “paired” Arctic grayling. The biopsy sample will be taken following the procedures detailed by Baker et al. (2004) using a commercially available dermal punch 5 mm in diameter. The sample will be placed into a sterilized vial, weighed, and put into a portable mini-freezer. Samples will be temporarily held in a chest freezer in Sleetemute until they can be expressed shipped to a laboratory for analysis.

3.2 Telemetry Procedures

The transmitters selected for this project are Lotek™ coded tags with motion sensors. Northern pike and burbot transmitters will operate for ~2.5 years and Arctic grayling for ~14 months. Radio tags will operate on 5 frequencies between 149.500 and 149.999 MHz with individual transmitters digitally coded for identification. Motion sensors will indicate when there is no movement for 24 hours or more, which would be indicative of a fish that has died or expelled its tag.

Radio tags will be located using a combination of ground-based tracking stations and aerial tracking surveys. Five tracking stations will collect movement information by recording fish passage, which are generally located on the: 1) mainstem Kuskokwim River near Aniak, 2) Holitna River approximately 1.5 km upstream from its mouth, Mainstem Kuskokwim river ~ 5 km downstream from the George River, Mainstem Kuskokwim ~ 5 km downstream from Stony Village, and Mainstem Kuskokwim at McGrath upstream from the Takotna River (Figure 1).

Data recorded from the tracking stations will be used to supplement and help interpret the aerial survey data. Based on other projects in the region, these tracking stations will only be operational from mid March to mid November when there is sufficient solar radiation. Recorded data will be periodically downloaded using a satellite modem.

Tracking flights will be conducted using a fixed wing aircraft and a Lotek SRX 600 receiver with an internal GPS that will record time and location data. Between early June 2012 and February 2014 approximately 11 flights will be flown (Table 3). The exact number, duration, and coverage of flights will be adjusted during the study based on weather conditions, pilot availability, costs, preliminary examinations of the data, and consultations with BLM. In general, flights will originate in Fairbanks and the Kuskokwim River will be surveyed en route to

Sleetmute, from which the remaining portions will be surveyed. The reach of the Kuskokwim River downsteam of the Aniak River will be flown less frequently because only Burbot will be present and the additional cost.   For example only one survey during summer and winter is needed ensure no major movements out of the 2012 study area (i.e. downstream of Aniak River) have occurred.

4.0 Sample Analysis

Descriptions of fish locations and distributions during each aerial survey will be presented and summarized by plotting coordinates of all located fish deemed to be alive at the time of the survey onto a digitized map of the drainage using the program ArcGIS®. A determination of mortality is at times a judgment call using the motion sensors and movement patterns, or lack thereof, and may require all flights to make a final assessment. Variables to be measured include:

1. net distance traveled between tracking events;
2. direction traveled between tracking events; and,
3. maximum distances traveled between seasonal habitats (i.e., range).

Patterns in transmitter locations will be used to infer fish behavior and habitat use, and aggregations of fish (e.g., number of radiotagged fish within a 0.5, 1.0, or 5.0 kilometer raduis) will be used to characterize significant spawning and overwintering habitats. For example, an aggregation of three or more fish within a 2-kilometer radius during late May would signify a potential spawning aggregation of Arctic grayling.

If significant (e.g. 5-10 fish) directional movement of northern pike, Arctic grayling or burbot occurs past a particular tracking station, run timing profiles will be constructed for each tracking station for the periods they are operable. Run timing profiles will be described as time-density functions, where tagged fish moving upstream and downstream of the tracking stations during time interval t will be described by:

$$f\left(t\right)=\frac{R_t}{\sum_{t=1}^{T} R_t} \qquad (3)$$

where:

f (t) = the empirical temporal probability distribution over the total span of movements (upstream or downstream) past a given tracking; and,

R_t = the subset of radio-tagged northern pike, Arctic grayling and burbot that migrated past the tracking stations during day t.

Residency time within a selected habitat or river section will be approximated from information garnished from the tracking stations and aerial surveys. These times will be approximated because the tracking stations (except for the Holitna River station) will not operate during most of the winter and the number of tracking flights will be limited (i.e., large temporal gaps). Nevertheless the data will provide evidence for generalized patterns.

length composition of catches

Length composition of all northern pike, Arctic grayling and burbot captured will be described by calculating mean length and length range for each sampling section. If sample sizes are adequate (e.g., 100 fish), length frequency histograms for each section will be constructed.

5.0 Data Analysis and Reporting

5.1 Metals analysis of biological samples

The intent of the biological sample analysis is to provide additional baseline data on the bioaccumulation of metals, including MeHg, in the middle Kuskokwim River and associated tributaries. Processed sample data by the contracted laboratory will be submitted for a third party quality assurance review before being considered complete.

Results from the metals analysis of samples collected from 2010-12 will be summarized in a series of reports. Telemetry tracking results will be integrated into the report as its collected and analyzed.

5.2 Schedules and Reports

A draft project report for BLM sampling would be compiled by May 2013 and finalized by August 2013. Telemetry data would be summarized in a final report in 2015.

5.3 Responsibilities

Project Leader: Matthew Varner, Fisheries Program Lead, BLM – AK State Office
Duties: Coordinate sampling effort, contract oversight, lead tributary sampling of biological resources, compile data, and author project report

Figure 2. Study Area

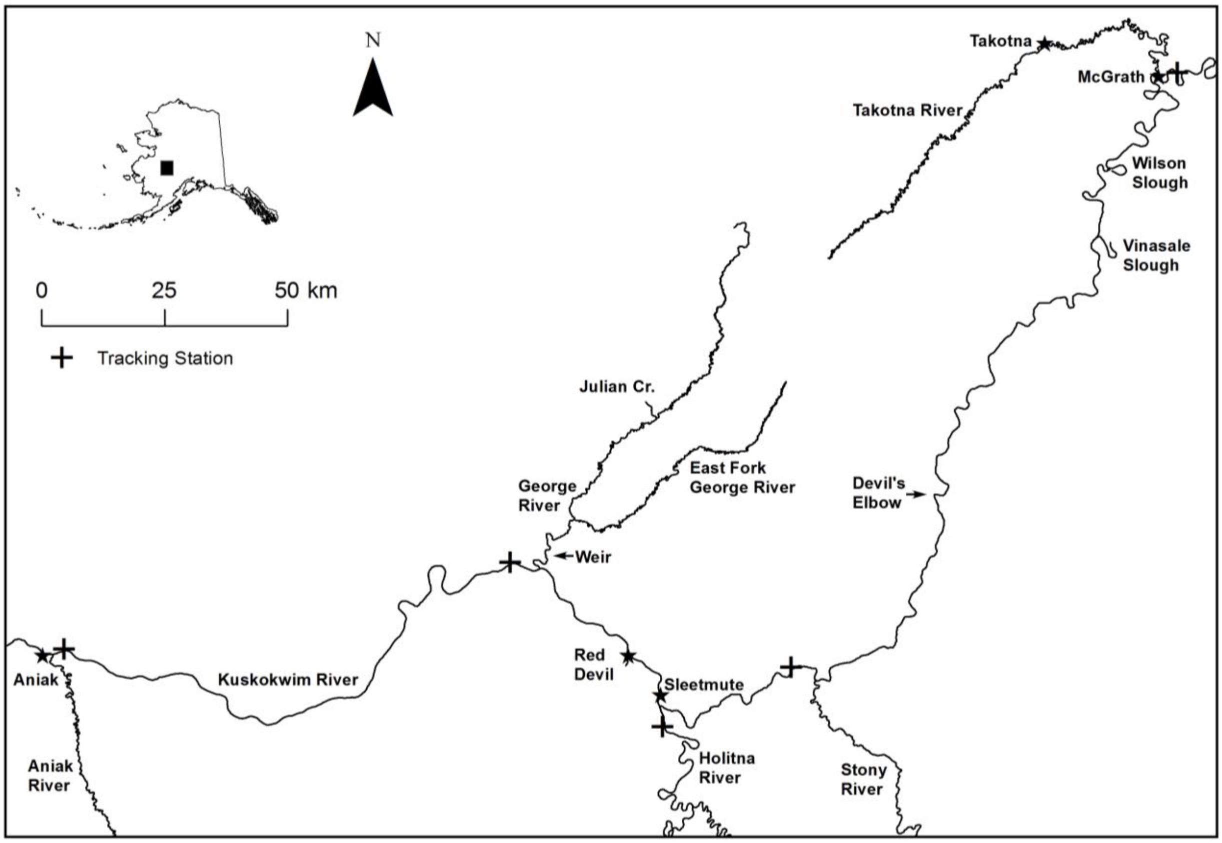


Table 1. Allocation of radio tags by species, and geographic, and length strata in the Middle Kuskokwim study area, 2012. Geographic strata are defined parenthetically.

Species	Study section	Length strata (mm FL)	Number of tags
Pike			
	Upper mainstem Kuskokwim	550 - 649	8
		650 - 749	12
		≥750	10
	Lower Takotna River	550 - 649	15
		650 - 749	10
		≥750	10
	Lower 20 km of George River	550- 649	10
		650 - 749	5
		≥750	5
			85
Arctic grayling			
	Lower mainstem (June sampling)	330 - 354	7
		355 - 380	7
		≥380	6
	Lower mainstem (October sampling)	330 - 354	16
		355 - 380	16
		≥380	16
	George River (Julian Creek to weir site, 42 km)	330 - 354	17
		355 - 380	17
		≥380	17
	Upper Takotna River	330 - 354	17
		355 - 380	17
		≥380	17
			170
Burbot			
	Lower Kuskokwim	500 - 599	17
		≥600	18
			35

Table 2. Schedule of aerial surveys for Arctic grayling, northern pike and burbot in the middle Kuskokwim River study area during June 2012 - February 2014

Tracking Flight #	Approximate Dates:	Primary purpose:
1	Early June, 2012[a]	Post break-up locations for burbot and pike, spawning locations of pike, summer feeding for burbot.
2	Early August, 2012[b]	Summer feeding locations of Arctic grayling, northern pike and burbot.
3	Early November, 2012 [b]	Post freeze-up locations.
4	Early December, 2012 [b]	Pre-spawning movements of burbot (lower Holitna and mainstem Kuskokwim only).
5	Mid January, 2013 [b]	Spawning locations of burbot (lower Holitna and mainstem Kuskokwim only).
6	Mid February, 2013 [b]	Post-pawning locations of burbot, and overwintering locations of northern pike and Arctic grayling.
7	Early April, 2013[c]	Pre-breakup locations for Arctic grayling, northern pike and burbot.
8	Late May, 2013[c]	Post break-up locations, and spawning locations of northern pike and Arctic grayling.
9	Early August, 2013[c]	Summer feeding locations of northern pike, Arctic grayling and burbot.
10	Late October, 2013[c]	Post freeze-up locations.
11	Early February, 2014[c]	Spawning locations of burbot (lower Holitna and mainstem Kuskokwim only).

[a] Pertains to fish tagged in 2011.

[b] pertains to fish tagged in 2011 and 2012.

[c] Only fish tagged in 2012 will still be viable.

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Appendix 1. Field Forms

<table>
<tr><td colspan="5">Macroinvertebrate Sampling Form (Metals)</td></tr>
<tr><td colspan="2">Stream Name:</td><td colspan="3">Sample Date:</td></tr>
<tr><td colspan="5">Site ID:</td></tr>
<tr><td colspan="5">Time Range (24h), HHMM-HHMM</td></tr>
<tr><td colspan="5">Sample Type:</td></tr>
<tr><td colspan="5">Field Crew:</td></tr>
<tr><td colspan="5">Field Comments:</td></tr>
<tr><td colspan="2">Species Common Name:</td><td colspan="3">Latin Name:</td></tr>
<tr><td colspan="5">Stream Habitat Sampled: Riffle Pool Run Margin</td></tr>
<tr><td>Composite #</td><td>Sample time (24h)</td><td># Individuals in Composite</td><td>Sample wet wt, field, g</td><td>Sample ID</td></tr>
<tr><td>1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td></td><td></td><td></td><td></td></tr>
</table>

Fish and Macroinvertebrate Sampling Form (Metals)				
Stream Name:		Sample Dates (YYYYMMDD)		
Site ID:				
Time Range (24h), HHMM-HHMM				
Gear Types:				
Field Crew:				
Field Comments:				
Species Common Name:		Latin Name:		
Stream Habitat Sampled:	Riffle	Pool	Run	Margin
Fish #	Sample time (24h)	Fork Length, total, mm	Fish wt, g	Sample ID
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				